A SPAWNING HABITAT MODEL TO AID RECOVERY PLANS FOR SNAKE RIVER FALL CHINOOK

9406900

SHORT DESCRIPTION:

Investigate whether interstitial flow pathways and ground-water/surface water interactions influence fall chinook salmon spawning site selection in the Hanford Reach of the Columbia River, and in cooperation with the other agencies, apply this information to Snake River fall chinook salmon recovery efforts.

SPONSOR/CONTRACTOR: PNNL

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GOALS

GENERAL:
Adaptive management (research or M&E)

ANADROMOUS FISH:
Research, M&E

NPPC PROGRAM MEASURE:
7.5B.3, 7.5B.5

RELATION TO MEASURE:

The protection and restoration of floodplain reaches within the Columbia and Snake river basins has been proposed as one strategy to increase fall chinook salmon production. Additional information on how floodplain reaches function within the mainstem of the Snake River to provide suitable fall chinook salmon habitat is needed (see Independent Science Group "Return to River" report). The above NPPC program measures call for increasing our understanding of the factors that limit fall chinook salmon production in the Snake River, including an identification of the spawning habitat requirements within the Snake River mainstem. This research project will provide empirical information directly related to these program measures.

OTHER PLANNING DOCUMENTS:

The general type of research that this project represents is recommended in the Independent Science Group's (ISG) report "Return to the River". The report places heavy emphasis on using the Hanford Reach of the Columbia River as a model and study area of "normative" river reaches. Further, the report recommends that the role of hyporheic flows and groundwater upwelling in salmon habitat utilization is an area that needs further study. This project will provide empirical demonstration of interstitial flow pathways and ground-water/surface water interactions. This type of research is critically needed in the Columbia River Basin in general and at Hanford in particular.

TARGET STOCK	LIFE STAGE	MGMT CODE (see below)
Hanford Reach upriver bright fall chinook salmon	Adults, eggs, pre-emergent fry	S
Snake River upriver bright fall chinook salmon	Adults, eggs, pre-emergent fry	N

AFFECTED STOCK	BENEFIT OR DETRIMENT
Other anadromous and resident salmonids	This project is a research project designed to investigate the role that sub-surface flows may play in river ecology, thus, the benefits to other aquatic organisms will be investigated indirectly

BACKGROUND

Stream name:	**Subbasin:**
Mid-Columbia (Hanford Reach) and upper-Snake River (upstream of Lower Granite to Hells Canyon	Mid-Columbia and upper-Snake River mainstems

Dam)

Hydro project mitigated:

N/A, the project is a research project that is designed to provide additional information on the life-history requirements of fall chinook salmon. The author of this form assumes this question applies to a production-type facility or habitat restoration effort designed specifically to mitigate impacts from a hydropower project. This is not the case for this project.

Habitat types:

Spawning and rearing of fall chinook salmon in the Hanford Reach and Snake River occurs in mainstem alluvial river reaches.

HISTORY:

This project was funded to compliment the research that is being conducted on the Snake River fall chinook salmon by the US Fish and Wildlife Service (USFWS). Prior to this project being funded, the research proposal was presented to the Snake River Fall Chinook Salmon Coordination Committee, and was reviewed by the USFWS, National Biological Service, Oregon Department of Fish and Wildlife, Idaho Power Company, and Washington Department of Fish and Wildlife (WDFW). Reviewers of the study supported the project because it compliments other research efforts presently underway in the Snake River basin. The project is designed to provide information to the National Marine Fisheries Service to be used in their efforts to prepare recovery goals for fall chinook salmon.

One goal of the Snake River fall chinook salmon recovery effort is to develop recovery plans that are based on reasonable estimates of production potential. This requires that fall chinook salmon spawning habitat be located and characterized. This study was proposed and funded as an effort to build upon existing studies that had been conducted in the Snake River in order to provide reasonable estimates of the potential spawning habitat for Snake River fall chinook salmon.

The low population size and study limitations imposed on protected stocks of Snake River fall chinook salmon hinders the implementation of some research projects. In contrast, fall chinook salmon populations that spawn and rear in the Hanford Reach have remained relatively stable over the last decade (Dauble and Watson 1990). Thus, our approach has been to use Hanford Reach fall chinook salmon as a study surrogate to Snake River fish. This is consistent with the Independent Science Group, and was approved by the funding agency (BPA) and the management and research agencies because:

(1) the Hanford Reach population is larger than the Snake River stock. This not only reduces the likelihood of harassing an endangered fish, but provides a wider representation of the conditions important for fall chinook spawning that would otherwise not be apparent in studying the Snake River population;

(2) the life-history pattern of both stocks are similar. Both stocks spawn in October and November. Emergence for both stocks occurs from March to May, and usually peaks in late April - early May. After emergence they spend from 1-3 months in the mainstem, and migrate to the ocean in July.

(3) there is over 40 years of monitoring data from the Hanford Reach, including analyses of flood plain, surface water, and groundwater processes, ecological processes, and fall chinook spawning habitat characterization. This information is necessary to develop a model of habitat selection that takes into consideration multi-dimensional aspects of river processes. This experience will be useful in directing future data needs for the Snake River.

(4) mainstem habitat characteristics of the riverine environment of both stocks are similar. The Hanford Reach is the last free-flowing section of the mainstem Columbia River and contains 51 miles of diverse habitat that is similar to that available in the Snake River downstream from Hells Canyon Dam. In both sections, upstream flow regulation influences habitat availability.

(5) on-going studies on the Hanford Site, currently funded for other purposes, are providing unique opportunities to transfer technology to the Snake River and other locations where anadromous fish populations are depressed. Presently, studies are being conducted to characterize groundwater input to the Columbia River and techniques developed to monitor the interaction of sub-surface flows and surface water will be useful in identifying the relationships between fall chinook spawning and groundwater processes.

BIOLOGICAL RESULTS ACHIEVED:

The physical characteristics (depth, substrate, velocity, and slope) of two fall chinook salmon spawning areas in the Hanford Reach have been described based on data collected in 1994 and 1995 (see Geist et al. 1997a). Additional data on the stage-discharge relationships was collected in 1996 and is presently being summarized.

Comparisons to fall chinook salmon spawning areas in the Snake River are presently being conducted in cooperation with the

USFWS. Preliminary results suggest that these "simple" descriptors of habitat do not adequately describe the amount of fall chinook spawning that occurs in the Hanford Reach (Geist et al. 1997a). This suggests that other descriptors are needed to provide accurate estimates of potential habitat for fall chinook salmon spawning in large rivers. We have initiated efforts to describe the spatial and temporal relationship(s) between geomorphic features of river channels (i.e., meander lengths, geologic land forms, gravel bars, etc.), channel hydraulics, and salmon spawning locations (Geist et al. 1997b).

One characteristic that appears to be critical for successful reproduction for many salmonids is sub-surface (i.e., interstitial) flow. In this proposal we refer to the subsurface zone of rivers and streams as the hyporheic zone. The hyporheic zone is characteristically a mixing zone that contains both groundwater and surface water, and is variable in spatial dimensions - it could extend a few meters to several hundred meters vertically and laterally to the river channel. We suspect that landform features (i.e., quality and depth of alluvium, channel configuration, longitudinal profile of river bed, and channel complexity) determine how extensive hyporheic zones area, and how the hyporheic zones affect the channel hydraulics within spawning areas.

In 1995 and 1996, we developed new techniques for installing devices to monitor the hyporheic zone within fall chinook spawning areas in the Hanford Reach (Geist et al. 1997c). This was previously not possible because of the difficulty in installing monitoring devices into the bottom of rivers with large substrate. Differences in hydraulic head between the hyporheic zone and water surface of the river were found, indicating that water is moving back and forth between the hyporheic zone and the river (i.e., upwelling and down welling). Preliminary results suggest, though do not necessarily prove, that fall chinook salmon are preferentially spawning in areas of positive hyporheic flow (Geist et al. 1996b). These areas of upwelling tend to be low in electrical conductivity which would indicate that river water is being forced into the river bed at some point upstream, traveling subsurface within the river bed, and then upwelling in salmon spawning areas. In contrast, in areas where fall chinook salmon do not spawn in high densities, there is limited upwelling and when upwelling does occur, the water is primarily groundwater. The implications of these findings are that the spawning habitat for fall chinook salmon in large, mainstem rivers is more limited than observations of depth, substrate, and velocity would suggest. In order to characterize quality of salmon habitat within a watershed, a consideration of hyporheic flows is necessary. The presence of hyporheic flows demonstrates that there are very well connected flow pathways between groundwater and surface water within floodplain reaches. These floodplain reaches, like the Hanford Reach, provide a model of how these flow pathways affect the distribution of spawning habitat for salmonids.

PROJECT REPORTS AND PAPERS:

Geist, D.R., D.D. Dauble, and R.H. Visser. 1997a. GIS data layers of suitable and unsuitable spawning habitat in relation to fall chinook salmon redd locations, Hanford Reach, Columbia River. FY 1995 and 1996 progress report, part A. Submitted to Bonneville Power Administration, Portland, Oregon.

Geist, D.R., R.H. Visser, and D.D. Dauble. 1997b. Spatial and temporal distribution of fall chinook salmon redds within the Hanford Reach of the Columbia River. FY 1995 and 1996 progress report, part B. Submitted to Bonneville Power Administration, Portland, Oregon.

Geist, D.R., M.C. Joy, D.R. Lee, and T.Gonser. 1997c. A new method for installing piezometers in large cobble-bed rivers. FY 1995 and 1996 progress report, part C. Submitted to Bonneville Power Administration, Portland, Oregon.

Geist, D.R., M.C. Joy, and D.R. Lee. 1996a. A method for installing piezometers within the hyporheic zone of a large cobble river. Bulletin of the North American Benthological Society, Annual Program Issue, Spring 1996, Volume 13, number 1.

Geist, D.R., P.E. Dresel, P.D. Thorne, and V.R. Vermuel. 1996b. Vertical gradients and electrical conductivity in the hyporheic zone of a large cobble bed river, relationship to ground-water upwelling zones near salmon spawning areas. Paper presented at the 1996 fall meeting of the American Geophysical Union, Volume 77, number 46, November 12, 1996.

Geist, D.R., and G. Johnson. 1996. Measuring current velocity, discharge, and river bathymetry with an acoustic doppler current profiler. Bulletin of the North American Benthological Society, Annual Program Issue, Spring 1996, Volume 13, number 1.

Lee, D.R., D. Hartwig, D.R. Geist, T.A. Cooper, and K.A. Saldi. 1996. Mapping groundwater discharge in the Hanford Reach of the Columbia River.   Paper presented at the Canadian Geophysical Engineers Meeting, Canada.

Lee, D.R., D.R. Geist, K. Saldi, D. Hartwig, and A.T. Cooper. 1997. Locating groundwater discharge in the Hanford Reach of the Columbia River. Completion report submitted to Pacific Northwest National Laboratory, Richland, Washington.

Dauble, D.D., and D.R. Geist. 1996. Rebuilding strategies for endangered stocks of Pacific salmon.   Paper presented at the 2nd annual World Fisheries Conference, Brisbane, Australia, July, 1996.

ADAPTIVE MANAGEMENT IMPLICATIONS:

Considerable effort is presently underway to rebuild and enhance native salmon and steelhead populations in the Columbia River basin. In order to formulate recovery goals and prepare recovery plans for Snake River salmon stocks, the production potential of salmon and steelhead under existing operating conditions is needed (SRSRT 1994; NMFS 1995a). Snake River salmon recovery plans include habitat protection and restoration (SRSRT 1994; NMFS 1995b). However, recovery efforts cannot be developed until we increase our understanding of the factors that limit the various life history stages (Rondorf and Miller 1993; SRSRT

1994). Presently there is a lack of information on the physical habitat features that limit production of salmon in large, free-flowing rivers (NPPC 1994; SRSRT 1994; NMFS 1995a; ISG 1996). This study is providing direct, empirical evidence that will show why Columbia River Basin fall chinook salmon select certain locations for spawning and rearing.

Water velocity, substrate size, and water depth are the principle variables used to describe mainstem spawning habitat for fall chinook salmon. However, these habitat characteristics vary considerably, both between and within major spawning areas. Suitable spawning habitat is more limited in many rivers than superficial observations of depth, velocity, and substrate would suggest. Models that predict suitable spawning habitat based on only these simple measures may tend to overestimate production potential. Inaccurate estimates of chinook salmon production may lead to unrealistic recovery goals for listed stocks.

Our general approach has been to use the fall chinook salmon of the Hanford Reach of the mid-Columbia as an analog of Snake River stocks. We are presently using characteristics of spawning habitat (both "simple descriptors" and more complex variables) from the Hanford Reach fall chinook stock to validate a model that the USFWS uses to predict fall chinook spawning habitat in the Snake River. This validation process is expected to result in a better model that can be used to provide more accurate assessments of production potential which will lead to reasonable recovery goals for Snake River fall chinook salmon

PURPOSE AND METHODS

SPECIFIC MEASUREABLE OBJECTIVES:

Provide empirical evidence that interstitial flow pathways and ground-water/surface water interactions are important determinants of fall chinook salmon spawning habitat.Translate information collected in the Hanford Reach of the Columbia River to on-going research and management issues in the Snake River.Specific questions this research will attempt to answer: Can the spatial and temporal variability of the physical characteristics within the hyporheic zone be used to explain the relationship between landform features (e.g., longitudinal gradient, channel configuration, depth of substrate, etc.) and channel hydraulics (e.g., depth, substrate, velocity, slope, etc.) that are important to where fall chinook salmon redds are located? Can this relationship be used to predict where future fall chinook salmon spawning will occur? Are the geomorphic processes in the Snake River similar to the Hanford Reach, and if so, would an evaluation of the spatial and temporal variability in the vertical hydraulic gradient of the hyporheic zone improve production estimates of fall chinook salmon?

CRITICAL UNCERTAINTIES:

A measurable hyporheic zone exists within fall chinook salmon spawning areas in the Snake River, and techniques developed in the Hanford Reach can be applied there.There are no significant risks to the environment associated with this project.

BIOLOGICAL NEED:

Additional information on the spawning habitat requirements of fall chinook salmon is needed because traditional fisheries models (i.e., depth, substrate, velocity) may not be suitable for estimating spawning habitat availability in large rivers. Without better information on spawning habitat requirements, recovery plans for ESA listed fish can not be developed. Unfortunately there are a limited number of healthy floodplain reaches which can be used as a model in which to study. The exception is the Hanford Reach. The Hanford Reach is a model of good salmon habitat and the fall chinook salmon stock that spawns and rears there is a model of a productive salmon stock. Thus, the Hanford Reach provides a template upon which information can be collected and applied to the Snake River population. In FY98 we are proposing to continue to collect information on how geomorphic processes (including hyporheic flows) affect fall chinook salmon spawning in large rivers. We believe that information we collect from on-going work in the Hanford Reach can be used to develop monitoring and evaluation efforts for the Snake River. This will be useful for developing recovery plans for Snake River fall chinook salmon.

Our general approach for this project has been to incorporate into existing models the characteristics of fall chinook salmon spawning habitat that are measured at various spatial and temporal scales. One characteristic that appears to be critical for successful reproduction in many salmonids is hyporheic flow (i.e., interstitial flow). Investigating the relationship between hyporheic flow and fall chinook salmon spawning had previously not been done before this study was initiated. We have made significant progress toward this effort since 1995. However, more information from the Hanford Reach and the Snake River is needed before a clear relationship can be established between the presence of hyporheic flows and the quality of fall chinook salmon spawning habitat.

Therefore, our effort in FY98 will focus on the relationships between the spatial and temporal variability of hyporheic flow and salmon spawning locations. We will attempt to explain how land-form features and the channel hydraulics within salmon spawning site are related via the hyporheic zone. We will evaluate whether these same data can be collected within fall chinook salmon spawning areas in the Snake River, and then evaluate the use of these findings to improving management of Snake River fall chinook populations.

HYPOTHESIS TO BE TESTED:

There are no differences in the physical characteristics of the hyporheic zone (e.g., vertical hydraulic gradient, temperature, electrical conductivity, or dissolved oxygen) between locations where salmon spawning occurs and locations where there is no spawning. This hypothesis will be tested within existing study areas in the Hanford Reach and depending on feasibility studies, possibly within new study areas in the Snake River.The alternative hypothesis is that there are differences in the physical characteristics of the hyporheic zone between locations where salmon spawning occurs and locations where there is no spawning.

ALTERNATIVE APPROACHES:

Alternative approaches to assessing spawning habitat of fall chinook salmon have been used in the past, but the predictive power of these approaches is limited because limited data that were collected over one scale were used. The approach we are proposing here puts the physical characteristics of salmon spawning areas within a watershed context where geomorphic features at larger scales are assumed to affect geomorphic features at smaller scales. We hypothesize that this approach will lead to more accurate estimates of production potential than current models.

JUSTIFICATION FOR PLANNING:

This project is already ongoing and any and all funds will be put toward accomplish project objectives.

METHODS:

Our study design will involve collecting data on hyporheic flows from two spawning sites in the Hanford Reach; Wooded Island and Locke Island. Each study site is ~3.5 km long and 300-400 m wide. These two areas were selected because traditional spawning habitat models predicted they should have similar amounts of spawning based on the distribution of water depth, velocity, slope, and substrate, yet the amount of spawning at each site is markedly different. Aerial spawner surveys over the last 40 years demonstrated that salmon spawned at the Wooded Island site infrequently (<50 redds per year) while at the Locke Island site spawning was much more frequent (>500-800 redds/year). This suggested that other variables were important in determining where salmon spawn. One of the variables we have been investigating is the physical characteristics of the hyporheic (sub-surface) zone. Our preliminary data from 1995 and 1996 suggest that this type of information can be used to partially explain the differences in spawning densities, however, additional information is needed in order to further refine and test some of our hypotheses. In FY98 we propose to continue investigating the differences in the hyporheic zone at these two sites.

During FY98 we are also proposing to investigate the feasibility of monitoring the hyporheic zone within fall chinook salmon spawning areas in the Snake River using the techniques we have developed in the Hanford Reach. During this first year our efforts in the Snake River will be primarily focused on determining if and where hyporheic flow may be located, whether we can get access to those sites in order to measure it, and whether there is any reason to believe hyporheic flow is related to salmon spawning locations in the Snake as it appears to be in the Hanford Reach. This approach is consistent with our original scope of work where we indicated we would transfer technology and information to the Snake River in an effort to improve predictions of spawning habitat utilization by fall chinook salmon. Additional field work in the Snake River will be conducted during FY99 and FY200. This aspect of our proposed efforts for FY98 will be closely coordinated with the US Fish and Wildlife Service, the Idaho Power Company, the Nez Perce Tribe, and the state fish and wildlife agencies from Washington and Idaho.

We have tentatively designed the following tasks to accomplish our FY98 objectives. These may change as planning and coordination continues.

Task 1. Evaluation of feasibility of conducting hyporheic studies in the mainstem of the Snake River (planning tasks). We will work closely with the above named agencies and tribes in an effort to determine whether hyporheic flow can be measured within mainstem fall chinook salmon spawning areas. If possible, we will test some sample designs and attempt to install piezometers in order to take preliminary measurements. However, during FY98 the focus of this task will be primarily a feasibility and planning task. Intensive field efforts would occur during subsequent years.

Task 2. Placement and Monitoring of Piezometers in two study areas in the Hanford Reach. We are proposing to use piezometers (Geist et al. 1997c) to monitor the hyporheic zone within the study areas. Piezometers consist of a perforated steel pipe (dia. ~4 cm) that is driven approximately 2 m into the river bottom within the river channel. Piezometers will be also installed in the middle of the river channel using a drive system mounted on a boat; this will be done in cooperation with C & M Specialty Services, Pasco, Wa. After piezometers are installed, measurements of water surface elevation, conductivity, temperature, and dissolved oxygen will be taken within the piezometer and within the river immediately adjacent to the piezometer. These measurements will be taken using a method randomly stratified over the sampling period (year-round). At key locations, sensors attached to data loggers will be deployed within piezometers and adjacent river stations to continuously monitor changes in elevation, temperature, and conductivity. Water surface elevations will be used to calculate the vertical hydraulic gradient between piezometer sampling depths. If the results of the planning task look favorable, we may test drive

some piezometers in fall chinook salmon spawning areas in the Snake River, and monitor the physical characteristics of the hyporheic zone.

Task 3. Measure vertical substrate composition within the two spawning areas in the Hanford Reach. We believe that the quality and depth of alluvial material within the spawning areas in the Hanford Reach is an important determinant of the amount of hyporheic flow. We propose to sample the vertical distribution of substrate material through the use of coring and/or excavation. This will be done during low flow conditions using standard procedures.

Task 4. Determination of Redd Location. Aerial photographs of fall chinook salmon spawning locations will be taken at weekly intervals beginning in mid-October continuing through mid-November in the Hanford Reach; a sub-contractor will need to be selected for taking and processing of aerial photographs. Locations of deep water redds will be mapped using underwater video and Global Positioning System technology. Redd locations will be digitized into an ArcInfo Geographical Information System. We may test whether we can photograph fall chinook salmon spawning downstream of Hells Canyon Dam. This information could be used to assess suitable spawning sites for monitoring hyporheic flow.

Task 5. Data Analysis. Information collected from the piezometers will be digitized and compared to spawning locations using quadrat methods and/or regression analysis. Data layers for salmon spawning and measures for the physical variables will be compared using spatial models developed in a GIS (e.g., ArcInfo). Within the Hanford Reach a likely scenario would involve using aerial photographs of salmon spawning from one year to develop a relationship with explanatory variables, and then use this relationship to predict spawning locations in 1997. This assumes physical variables are constant year to year at any given discharge. Aerial photographs taken in 1997 would be used to test the accuracy of the predictions. Goodness of fit (e.g., chi square) tests will be done to compare how well predictions match observed (Ludwig and Reynolds 1988). Data collected in the Hanford Reach will be compared to preliminary data collected in the Snake River (if there are any). Comparisons will include an assessment of the probability an extensive hyporheic corridor exists within the Snake River spawning areas, and whether this hyporheic corridor appears to be related to where fall chinook salmon spawn. A recommendation on the feasibility to continue with installation of piezometers in the Snake River will be provided.

Task 6. Prepare report. This will likely include more than one chapter, with individual chapters dedicated to the evaluation of the results from the feasibility study within the Snake River, results of 1997-98 data from piezometers from the Hanford Reach, and the comparison of the potential for an extensive hyporheic corridor within the spawning areas in the Snake River

PLANNED ACTIVITIES

SCHEDULE:

Planning Phase	**Start** 10/1/97	**End** 9/1/98	**Subcontractor**

Task Task 1. Evaluation of feasibility of conducting hyporheic studies in the mainstem of the Snake River

Implementation Phase	**Start** 8/1/98	**End** 9/25/98	**Subcontractor**

Task Task 6. Prepare report.

Implementation Phase	**Start** 1/1/98	**End** 8/1/98	**Subcontractor**

Task Task 5. Data Analysis.

Implementation Phase	**Start** 10/1/97	**End** 9/30/98	**Subcontractor** Yes for aerial photographs, unknown at this time

Task Task 4. Determination of Redd Location.

Implementation Phase	**Start** 10/1/97	**End** 9/30/98	**Subcontractor** Not known at this time

Task Task 3. Sample vertical distribution of substrate within two study areas in Hanford Reach.

Implementation Phase	**Start** 10/1/97	**End** 9/30/98	**Subcontractor** C&M Specialty Services

Task Task 2. Placement and Monitoring of Piezometers in two study areas in the Hanford Reach.

PROJECT COMPLETION DATE:

2000 (Continuation of this project beyond FY98 will be needed in order to develop adequate comparisons between Hanford Reach and Snake River)

CONSTRAINTS OR FACTORS THAT MAY CAUSE SCHEDULE OR BUDGET CHANGES:

A hydraulic project approval will be required to install piezometers into the river channel within the Hanford Reach in Washingto

n State. This is not expected to cause delays, but will require coordination with state and federal agencies, and affected Indian tribes.We are proposing to possibly install piezometers in the Snake River in order to monitor hyporheic corridor near salmon spawning areas. This will require approval and coordination among landowners, management agencies, and other interested parties. This may affect our ability to complete installation during optimal field conditions.

OUTCOMES, MONITORING AND EVALUATION

SUMMARY OF EXPECTED OUTCOMES

Expected performance of target population or quality change in land area affected:
This study is designed to provide information toward increasing our understanding of the factors that limit production of fall chinook salmon in large rivers. This information will be essential in defining critical habitat areas and recovery plans for salmon stocks throughout the basin, especially Snake River fall chinook salmon. If spawning habitat of salmonids is more limited than measures of depth, substrate, and velocity would suggest, we might assume that spawning habitat for salmonids is not limited and protection/restoration of spawning habitat would not necessarily be a key part of salmon recovery plans. If this assumption is wrong, we risk losing production by not protecting critical spawning habitat or missing opportunities to improve spawning habitat. Preliminary evidence from salmon spawning studies like this one (and a preponderance of information for other river ecology studies) suggest that simplistic variables like depth, substrate, and velocity are not adequate for describing salmonid habitat.
The multi-dimensional aspects of river systems are not well understood. We believe this study will provide evidence that rivers are not bound systems, and that connectivity within the landscape can be used to improve our definition of salmon habitat. This study will provide a mechanism to include these aspects in future efforts to model production potential of salmon.
Although the hyporheic zone has been studied, little is known about the importance of the hyporheic zone to chinook spawning habitat. This study is expected to provide a better understanding of the geomorphic processes (including hyporheic flow) in a large river. In the process of studying these processes, new techniques that can be used to analyze spatial data and examine relationships between hyporheic flow and fish habitat will also be developed

Present utilization and convservation potential of target population or area:
The Hanford Reach fall chinook salmon stock meets escapement goals each year, while the fall chinook salmon that return to the Snake River are at a fraction of their historical levels. Fall chinook salmon spawning primarily occurs in floodplain reaches of the mainstems of rivers, however, floodplain reaches of the mainstem Columbia and Snake rivers are limited to short sections like the Hanford Reach and the Hells Canyon Reach. If more of these areas could be restored, the production of fall chinook in the Snake River might be increased.

Assumed historic status of utilization and conservation potential:
We assume that floodplain reaches like the Hanford Reach were once centers of salmon productivity. This was likely because these areas were typically located near the confluence of two or more rivers, and consisted of well connected groundwater-surface water flow pathways that created maximum environmental heterogeneity across the width of the floodplain. This created a mosaic of habitat types and provide spawning and rearing areas for a number of diverse life history types.

Long term expected utilization and conservation potential for target population or habitat:
One strategy to increase salmon production within the Columbia River basin would be to restore floodplain reaches within tributaries and mainstems. If salmon production could be increased within these sections, this would likely result in recruitment into areas that are presently under-seeded. This would tend to increase overall production of salmon within the Columbia River basin.

Contribution toward long-term goal:
This project will provide information on the importance to salmon spawning from hyporheic flows within floodplain reaches. This research is an empirical demonstration of interstitial flow pathways and ground water/surface water interactions. This information could then be used in restoration and management efforts.

Indirect biological or environmental changes:
If we are able to demonstrate that the physical connections between groundwater and surface water are important in fall chinook s

almon spawning habitat, we will be in a more informed position for making long-term management decisions for restoration activities in the Columbia basin.

Physical products:
NA, this project will not provide physical products, but rather a better understanding of the important physical processes that influence where salmon spawn and rear.

Environmental attributes affected by the project:
NA, this project is a research project that is designed to investigate the importance of interstitial flow pathways to determining where salmon spawn.

Changes assumed or expected for affected environmental attributes:
NA, this project is a research project that is designed to investigate the importance of interstitial flow pathways to determining where salmon spawn.

Measure of attribute changes:
NA, this project is a research project that is designed to investigate the importance of interstitial flow pathways to determining where salmon spawn.

Assessment of effects on project outcomes of critical uncertainty:
NA

Information products:
The project will provide a series of technical reports that will include recommendations on the importance of improving our understanding of the role that groundwater - surface water interactions play in determining where fall chinook salmon spawn.

MONITORING APPROACH
This question pertains specifically to a project that requires monitoring (habitat enhancement, hatchery, etc.) and not necessarily to a research project. The overall success of our project will be how scientifically valid the data are (i.e., high QC), how we interpret the results, and how well we can relate the results to management alternatives presently being evaluated by the fish and wildlife management agencies.

Provisions to monitor population status or habitat quality:
We are presently developing techniques that could be used to assess how hyporheic flows affect the amount of fall chinook salmon spawning habitat in large, mainstem rivers. Thus, our research is providing an empirical demonstration of the role that interstitial flow and groundwater - surface water interactions play in the floodplain reaches of large, mainstem rivers. This will ultimately be used to assess how other floodplain reaches could contribute to salmon production, and could be used to assess the relative benefits of flow management scenarios (i.e., pulsed flows, drawdown).

Data analysis and evaluation:
NA, We have explained how the data will be analyzed in the above methods section. This question is geared toward the M&E requirements of a "project" and hence, is not applicable.

Information feed back to management decisions:
NA, again this question is not relevant to a research project as we are proposing here.

Critical uncertainties affecting project's outcomes:
A broader research need could be to incorporate this type of research into monitoring floodplain reaches at the sub-basin scale.

EVALUATION
The overall performance measure of this project will be dependent on the results we obtain, and how well we can transfer the resul

ts from the Hanford Reach into management options for the Snake River.

Incorporating new information regarding uncertainties:

We participate in the Snake River Fall Chinook Coordination Committee and regularly attend research coordination meetings. We also interact on a regular basis with WDFW, Yakama Indian Nation, and USFWS so that we can discuss research results as they become available, and make any necessary changes as needed. Any changes that are made are discussed with members of CBFWA and BPA.

Increasing public awareness of F&W activities:

This research project will provide a direct demonstration of the importance of interstitial flow pathways and groundwater-surface water interactions to the location selected by fall chinook salmon for spawning. Because most of the research is being conducted in the Hanford Reach, our results will be highly visible because of the management decisions land-use planners are presently faced with at Hanford (Wild and Scenic Rivers, Hanford Site Cleanup, etc.). We are continually asked by local citizen groups, management agencies, and politicians to discuss the importance of the Hanford Reach to fall chinook salmon production. This will ultimately increase public support for the Fish and Wildlife Program.

RELATIONSHIPS

RELATED BPA PROJECT	RELATIONSHIP
9603201 Hanford K-Basin Fall Chinook Acclimation, Yakama Indian Nation	The study proposed here and the referenced project are being conducted in the Hanford Reach on the same stock. The referenced project is evaluating the effectiveness of using supplementation to diversify the spawning locations of fall chinook salmon adults. Thus, information that we have been collecting on habitat types and salmon spawning locations will be provided to the Yakama Indian Nation. This information will aide them in designing release strategies and conducting monitoring and evaluation studies.
5503800 1996-97 Evaluation of Juvenile Fall Chinook Stranding in the Hanford Reach, Washington Department of Fish and Wildlife.	We are presently assisting WDFW in the implementation of the referenced project. The study proposed here and the referenced project are being conducted in the Hanford Reach on the same stock. Thus, information that we have been collecting on habitat types, flow-stage relationships, and hyporheic zones is being provided to WDFW. This information will aide WDFW in designing study locations, collecting data, and interpreting results.
9403400 Assessing summer and fall chinook salmon spawning, incubation, growth, and outmigration timing in the upper Clearwater, lower Salmon, Grande Rhonde, and Imnaha rivers, Nez Perce Tribe.	The project proposed here will assist in assessing the fall chinook salmon spawning requirements in the rivers being investigated by the Nez Perce Tribe. We are presently sharing information with the Nez Perce Tribe through the Fall Chinook Coordination Committee
9204600 Upstream passage, spawning, and stock identification of fall chinook salmon in the Snake River, Washington Department of Fish and Wildlife.	Understanding the habitat requirements of Snake River and Hanford Reach fall chinook salmon may help in explaining the straying of fall chinook salmon adults that WDFW observed in this study.
9102900 Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin, U.S. Fish and Wildlife Service/National Biological Service.	Cooperators on the referenced project (i.e., US Fish and Wildlife Service/National Biological Service) are assisting and/or involved in the project proposed here
9102900 Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin, U.S. Fish and Wildlife Service/National Biological Service.	

RELATED NON-BPA PROJECT	**RELATIONSHIP**
Hanford Site Wildlife Resources/Department of Energy	PNNL has a task on the referenced project to monitor fall chinook salmon spawning in the Hanford Reach as part of DOE's site-wide wildlife monitoring project. Data collected from aerial surveys will be used in the proposed project.

OPPORTUNITIES FOR COOPERATION:

Ongoing cooperation is occurring between the fall chinook salmon juvenile stranding project being conducted by WDFW. We are sharing resources, including GIS data layers. I anticipate there will be a potential to share in field equipment. Ongoing cooperation is also occurring between the USFWS and Battelle. We are working together to refine the habitat requirements of spawning fall chinook salmon using some of the data collected from this project. Additional cooperation is expected between Battelle and Idaho Power Company.

COSTS AND FTE

1997 Planned: $165,000

FUTURE FUNDING NEEDS:

FY	$ NEED	% PLAN	% IMPLEMENT	% O AND M
1998	$300,000			100%
1999	$400,000			100%
2000	$300,000			100%

PAST OBLIGATIONS (incl. 1997 if done):

FY	OBLIGATED
1994	$229,770
1996	$25,000
1997	$165,000
TOTAL:	$419,770

Note: Data are past obligations, or amounts committed by year, not amounts billed. Does not include data for related projects.

OTHER NON-FINANCIAL SUPPORTERS:

NA

LONGER TERM COSTS: NA

1997 OVERHEAD PERCENT:

The 1997 overhead rate at Battelle, PNNL is 65 to 105%. This is an average percent for interagency task orders between BPA and Richland Operations. The actual percentage depends on the mix of direct costs (labor, procurement, travel, and subcontracts).

HOW DOES PERCENTAGE APPLY TO DIRECT COSTS:

The actual percentage of the overhead that applies to direct costs depends on the relative mix of direct costs.

CONTRACTOR FTE:

The proposed budget for this project in FY98 will be used to partially fund several PNNL staff persons. The mix of specific PNNL staff, sub-contractors, and student help has not been determined for the proposed work. Therefore, it is not possible to estimate the total FTEs within PNNL that will be supported by this project.

SUBCONTRACTOR FTE:

The proposed budget for this project in FY98 will be used to partially fund several staff from subcontractors. The mix of specific PNNL staff, sub-contractors, and student help has not been determined for the proposed work. Therefore, it is not possible to estimate the total FTEs within subcontractors that will be supported by this project.